National Park Service/Buffalo National River

Elk in Arkansas: Exponential Growth and Decay

Overview:
In “Elk in Arkansas”, students will learn some basic information about elk in Arkansas and will utilize data on the growth of the elk population to predict future population numbers.

The curriculum is divided into two programs, a traditional classroom model and a computer lab model. Each program takes approximately one to two class period(s) to complete with extensions available for extra days.

Grade level: 9-12th grades (may also be appropriate for advanced 7/8th grade classes)

Duration: One to two 40 minute class periods

Group size: 2 to 4 students

Subject areas: Algebra, Biology, Ecology

Common Core Curriculum Standards:

CCSS.Math.Content.HSA-CED.A.1 - Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions*.

CCSS.ELA-Literacy.RST.9-10.7 - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

National Science Standards:

NS.9-12.5 - Science and Technology
NS.9-12.6 - Personal and Social Perspectives

Arkansas Science Frameworks:

NS.13.B.1 - Collect and analyze scientific data using appropriate mathematical calculations, figures, and tables

BD.2.ES.9 - Explain how limiting factors affect populations and ecosystems

Elk in Arkansas – Exponential Growth Activity
Traditional Classroom Model

Prerequisites:
Students should have familiarity with entering data into a calculator table and using the data to generate a graph and line of best fit. They should understand the concepts of growth and decay. The students should also have the ability to identify types of graph given its shape; linear, quadratic, or exponential. For the extension activity, the students will use computer simulation models to predict outcomes.

Objectives:
At the end of the lesson, students will be able to:
1) Name at least 4 characteristics of elk
2) Explain the causes for the decline of the original Ozarks elk
3) Explain the re-population process for elk into the Buffalo River area
4) Generate and identify an equation for exponential growth using given data
5) Use their equation to predict the growth for any given time period

Instructional resources needed:
Background information page
Calculators – 1 or 2 per group
Data sheets – 1 per group
Grid poster board – 1 per group
Markers – as many as available
(Computers for simulation activity in extensions)

Time required:
One to two class period(s) for activity
One additional class period for the extension activity

Procedures:
Set:
1) Show the introduction video "Elk of Arkansas" - http://vimeo.com/56654684
   Note: This is a long video broken into segments; the teacher may want to preview the video first to decide which parts to show the class.
2) Have the students read the student resource page 1; *Background: Elk Repopulation in Arkansas* (see the differentiation section for alternative ways to present the material)
3) Facilitate a class discussion and have the students generate a class/group* concept map** of the following:
   What are the basic characteristics of elk?
   What were the reasons for decline of elk in the Ozarks?
   When/How were elk re-introduced the Buffalo National River?

*The teacher may want each group to create its own concept map and then have each group display its map along with its graph and equation.

** An example, blank, and modified concept maps are included as teacher resource pages 3-5

4) Pose the scenario, “Arkansas Game and Fish is concerned within the next 10 years there will not be enough grazing areas to support the number of elk if the growth rate continues as it has previous years. They have asked us to calculate what the Buffalo River elk population will be in 10 years. How can we best do that?”
5) Generate student responses; hopefully at least one student should respond with “by generating a growth equation”; if no student does so, the teacher may want to suggest it.

Teach:

1) Generate/facilitate class discussion on the best axis labels/units to use for graphing the data
2) Once the class has decided on what axis labels/units to use, have the students get into pairs or small groups to do the remaining activities.
3) Tell the students they will be:
    a. Creating a graph of the data on their poster board using the class labels/units
    b. Entering the data into their calculator; generating the graph and line of best fit from the data (their calculator graph should match their poster graph)
    c. Generate and identify an equation that could be used to predict population numbers for elk as a function of year
    d. Predicting what the elk population will be for the current year* and for ten years from now. (*the year will change as this activity is used in future years)
4) Have the students put the following on their poster board:
    a) Graph with appropriate labels; identify the type of graph
    b) Line of best fit
    c) Equation and predictions
5) Have the students display their posters in the classroom

Closure:

The teacher will facilitate a class discussion on:

1) Accuracy of concept maps (if done by individual groups)
2) Which equation(s) work(s) best; what type of equation it (they) are
3) The future prediction results

If time permits:

Facilitate a class discussion on:

1) Why there is no population data for some years.
2) Possible factors that may have affected the population numbers in the past and may affect them in the future. (A tie-in to ecology could occur here.)
3) What else would Game and Fish need to know in order to know if there will be enough grazing area in ten years? (A tie-in to biology and/or ecology could occur here.)

Assessment:

The next day, the students will use a similar activity to complete using data for African elephants (exponential decay; teachers’ resource page 8). Students are required to complete the activity sheet which will serve as a grade. A sample vocabulary worksheet/quiz is also included as teacher page 7.

After completing work on all three types of graphs, linear, quadratic, or exponential the students will take a unit test over them.

Differentiation:

Some strategies to consider:

1) Reading the information sheet aloud to non-readers
2) Highlighting/posting the information sheet for poor readers
3) A modified concept map is included as Teacher Resource Page 3
4) More advanced students:

Have them explore using an intrinsic rate of increase equation to predict what the elk population will be in 10 years. The teacher will facilitate a class discussion comparing the students' equations and prediction results to the intrinsic equation and its prediction results. The class could also discuss what effect legal hunting has had on the actual population growth since 1998 and if that effect fits the intrinsic model.

Sample Extension Activities:

Have each pair of students work with a partner to predict what the Ozark elk population would be in 10 years for each of the following situations:

1) 25% of the total number are lost each year due to disease and hunting
2) Have the students create and explain to the class a simulation of their own making

Possible Class Field Trip:

There is an Elk Education Center located at Ponca, Arkansas that offers a wealth of information on the elk and other wildlife located in the area. It's open from 10:00am to 4:30pm every day except Tuesday and Wednesday. There's no fee, but it would be best to call ahead to schedule groups. A brochure is included in this lesson plan as teacher resource page 9.

Elk in Arkansas – Exponential Growth Activity
Computer Classroom Model

Prerequisites:

Students should know to enter data into a computer spreadsheet to generate a scatter plot graph with linear regression. For the extension activity, the students should become familiar with using computer simulation models to predict outcomes.

Objectives:

At the end of the lesson, students will be able to:

1) Name at least 4 characteristics of elk
2) Explain the causes for the decline of the Ozarks elk
3) Explain the re-population process for elk into the Ozarks
4) Generate an equation for exponential growth using given data
5) Use their equation to predict the growth for any given time period

Instructional resources needed:

Blank concept map (teacher resource page 5)
Computer – 1 per group

Time required:

One to two class period(s) for activity
One additional class period for the extension activity

Procedures:

Set:

1) Show the introduction video "Elk Of Arkansas" - http://vimeo.com/56654684
   Note: This is a long video broken into segments; the teacher may want to preview the video first to decide which parts to show the class.
   This is an additional/optional slide show presentation from Arkansas Game and Fish
2) Pose the scenario, "Arkansas Game and Fish is concerned that in 10 years there will not be enough grazing areas to support the number of elk if the growth rate continues as it has in the past. They have asked us to calculate what the Buffalo River elk population will be in 10 years. How can we best do that? "
3) Generate student responses; hopefully at least one student should respond with "by generating a growth equation"; if no student does so, the teacher may want to suggest it.

Teach:

1) Tell the students they will be:
   a. Locating/identifying enough information about elk to complete the concept map
   b. Locating and printing off the population numbers for elk in the Buffalo River region of Arkansas for the years 1985 to present (remind them to include their source; the teacher may want to have copies of the data available in case of computer issues)
   c. Creating a graph of the data on their computer – the teacher may want to have the students stop and discuss as a class which axis/units to use for graphing after the data is found
   d. Entering the data into their computer; creating the graph and line of best fit from the data

e. Generating and identifying an equation that could be used to predict population numbers for elk as a function of year
f. Predicting what the elk population will be for the current year* and for ten years from now. (*the number of years will change as this activity is used in future years)

2) Have the students display their work in an appropriate way to facilitate classroom discussion; they must include:
   a. The completed concept map
   b. Graph with appropriate labels; identify type of graph
   c. Line of best fit
   d. Equation and predictions

Closure:

The teacher will facilitate a class discussion on:

1) Some characteristics of elk.
2) The decline and re-population of elk in the Ozarks.
3) Which equation(s) work(s) best; what type of equation it (they) are.
4) The future prediction results.

If time permits:

Facilitate a class discussion on:

1) Why there is no population data for some years
2) Possible factors that may have affected the population numbers in the past and in future years (A tie-in to ecology could occur here.)
3) What else would Game and Fish need to know in order to know if there will be enough grazing area in ten years? (A tie-in to biology and/or ecology could occur here.)

Assessment:

The next day, the students will be given a similar activity to complete using the data for African elephants (exponential decay; teacher resource page 8). They will be required to complete the activity sheet which will be used for a grade.

After completing work on all three types of graphs, linear, quadratic, or exponential the students will take a unit test over them.

Differentiation:

Some strategies to consider:

1) Reading the information sheet aloud to non-readers
2) Highlighting and giving the information/data sheets to poor readers
3) A modified concept map is included as teacher resource page 4
4) More advanced students:
   Have them explore using an intrinsic rate of increase equation to predict what the elk population will be in 10 years. The teacher will facilitate a class discussion comparing the students' equations and prediction results to the intrinsic equation and its prediction results. The class could also discuss what effect legal hunting has had on the actual population growth since 1998 and if that effect fits the intrinsic model.

Sample Extension Activities:

Have each pair of students work with a partner to predict what the Ozark elk population would be in 10 years for each of the following situations*:

1) Each cow has twins for 1 of the ten years; the annual rate of births is 50% cows, 50% bulls
2) 25% of the total number are lost each year due to disease and hunting
3) Have the students create and explain to the class a simulation of their own making

Possible Class Field Trip:

The Elk Education Center located at Ponca, Arkansas and offers a wealth of information on the elk and other wildlife located in the area. It's open from 10:00am to 4:30pm every day except Tuesday and Wednesday. There's no fee, but it is best to call ahead to schedule groups. A brochure is included in this lesson plan, teacher resource page 9.

The Hilary Jones Wildlife Museum and Elk Information Center is located in Jasper, Arkansas and also has lots of information about elk. They are open 7 days a week, from 9:00 AM to 5:00 PM, and can be reached at 870-446-6180 or at newtoncoinfo@ritternet.com.

Background: Elk Repopulation in Arkansas

What are elk?
Elk are large members of the deer family.

Were there always elk in Arkansas?
An eastern subspecies of elk was native to the hardwood forest of the Ozarks region of Arkansas before, and during, the time of the first settlers. As the number of settlers grew, they cleared much of the elk habitat for farms and hunted the elk for meat. Eventually the loss of habitat and loss of numbers took its toll and elk were not found in Arkansas after the 1840s. They were considered extinct by the end of the century.

How did the elk get re-established in Arkansas?
In 1933, the USDA Forest Service transported 7 elk, 3 bulls and 8 cows, from the Wichita National Wildlife Refuge in Oklahoma and released them in Franklin County's Black Mountain Refuge in Arkansas. In the 1950s the herd had increased to about 200. Shortly thereafter, the elk disappeared. Experts think that illegal hunting, disease, loss of habitat, and natural causes led to their disappearance.

Then in 1981, the Arkansas Game and Fish Commission began a program to re-introduce elk back into the Ozarks region. The Commission traded young Ozark crappie and largemouth bass for Rocky Mountain elk from Colorado. The first trade was for 7 elk, 1 bull, 3 pregnant cows, and 3 older calves. The 7 elk were released in the Upper Buffalo River area, near Erbie, in March of 1981. Later trades with Colorado and Nebraska resulted in a total of 112 elk being brought into the Buffalo National River area. The herd has now grown to number approximately 600.

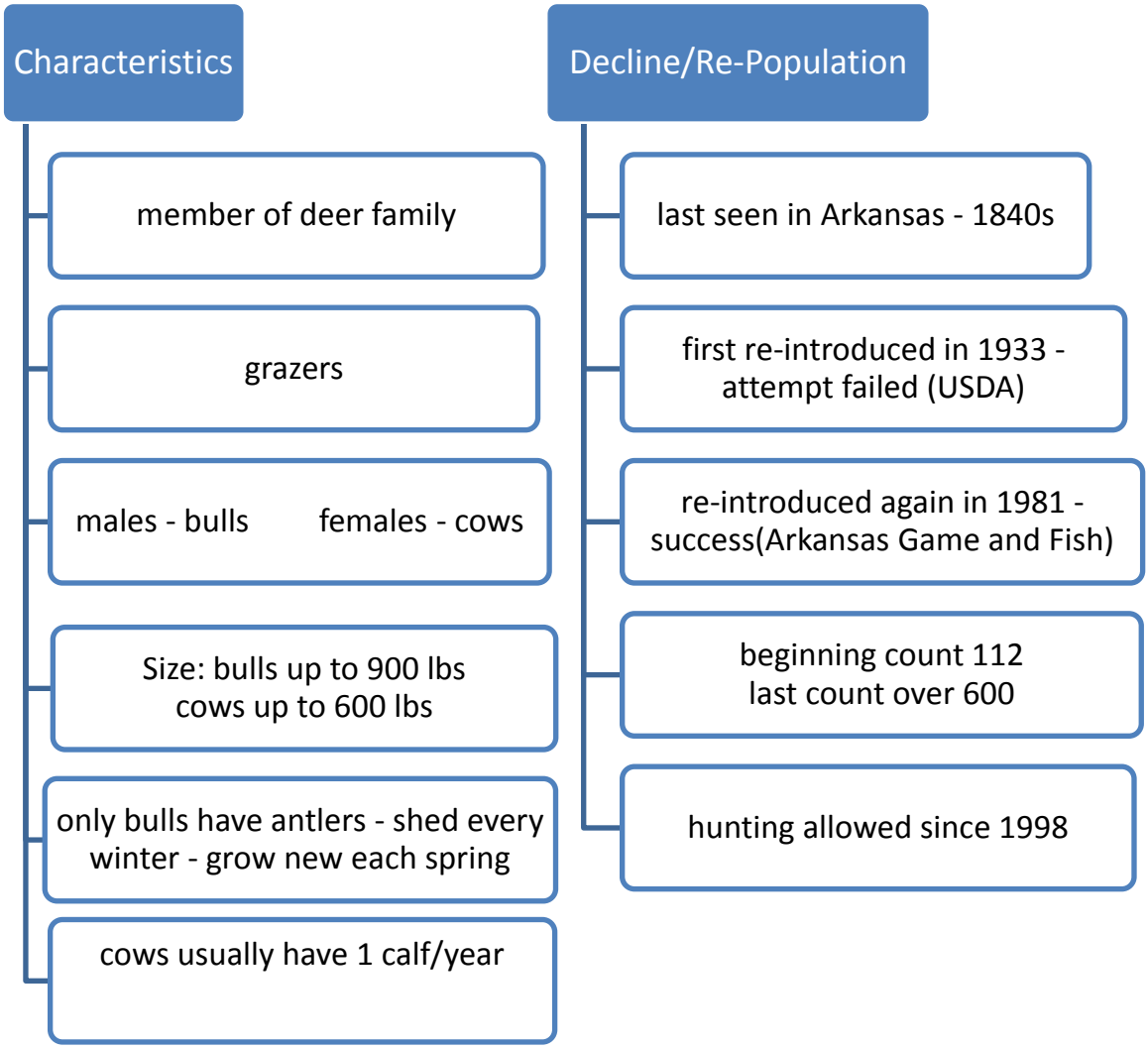
Some characteristics of elk:
- Male elk, called bulls, on average stand about 5 ft. tall at the shoulder, are 9 feet long and can weigh up to 900 pounds.
- Female elk, called cows, are on average about ¾ the size of bulls weigh only 500-600 pounds.
- Bulls grow new antlers every spring which they then shed in late winter; the antlers may reach 5 feet in length and weigh up to 25 pounds.
- Female usually have one calf per year; twins do occur occasionally.
- Elk are grazers who eat all kinds of plants, shrubs, and twigs, and small trees, but they prefer grass.

Are people allowed to hunt elk?
Arkansas early hunters shot native elk up until the 1840s when they were considered extinct. Hunting was not permitted on the re-introduced elk until 1998 at which time their numbers were considered stable. Elk hunting permits are issued by random drawing held during the Buffalo River Elk Festival held at Jasper, Arkansas during the month of June. Private land permits to hunt elk are issued using a quota system. A total of 59 permits were issued for 2013.

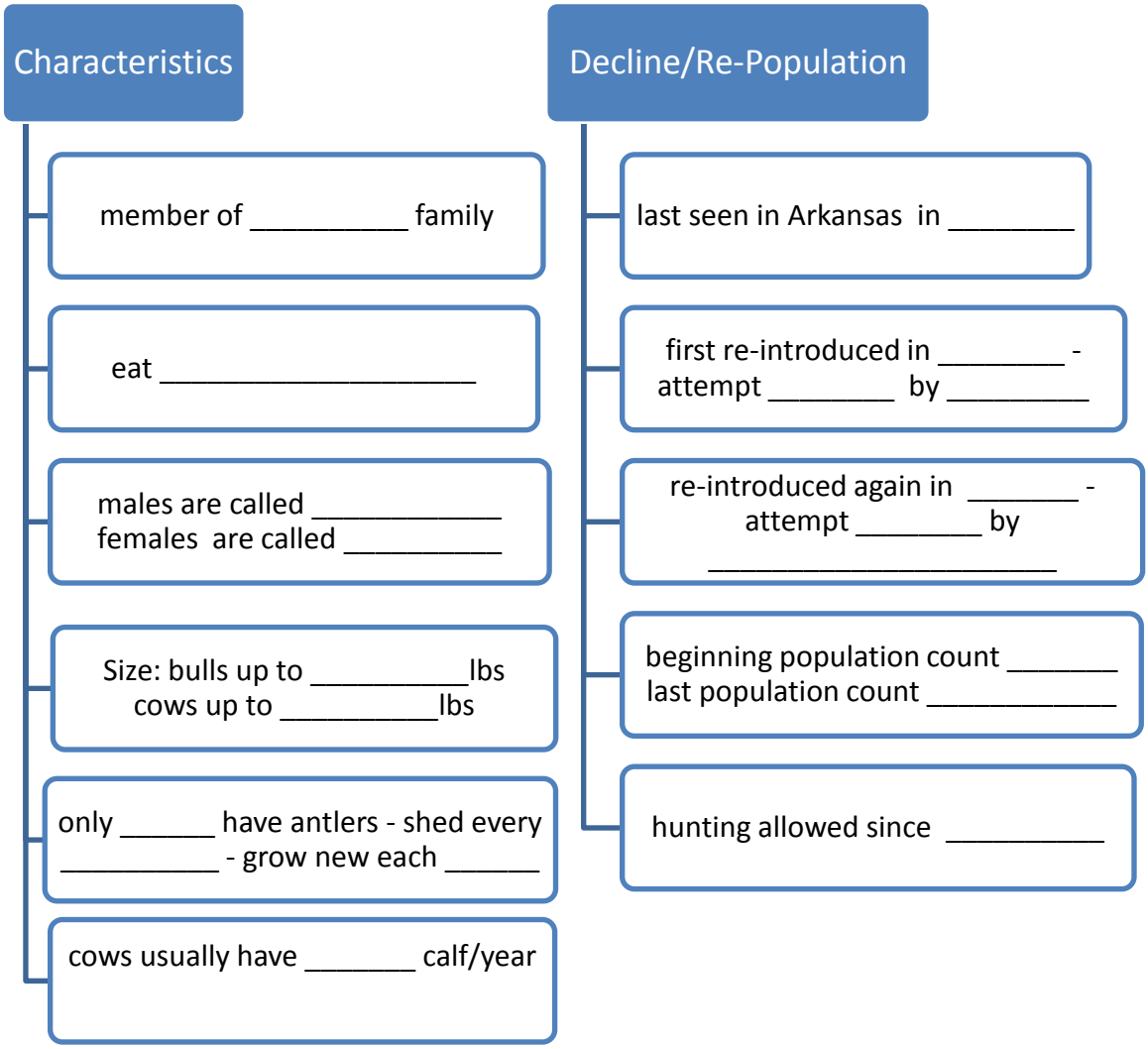
Elk Population Data – 1985 to 2012

Year	Population
1985	112
1985 – 1990	no data found
1991	76
1992	142
1993	no data found
1994	312
1995-2001	no data found
2002	197
2003	220
2004	266
2005	312
2006	321
2007	346
2008	345
2009	243
2010	392
2013	620

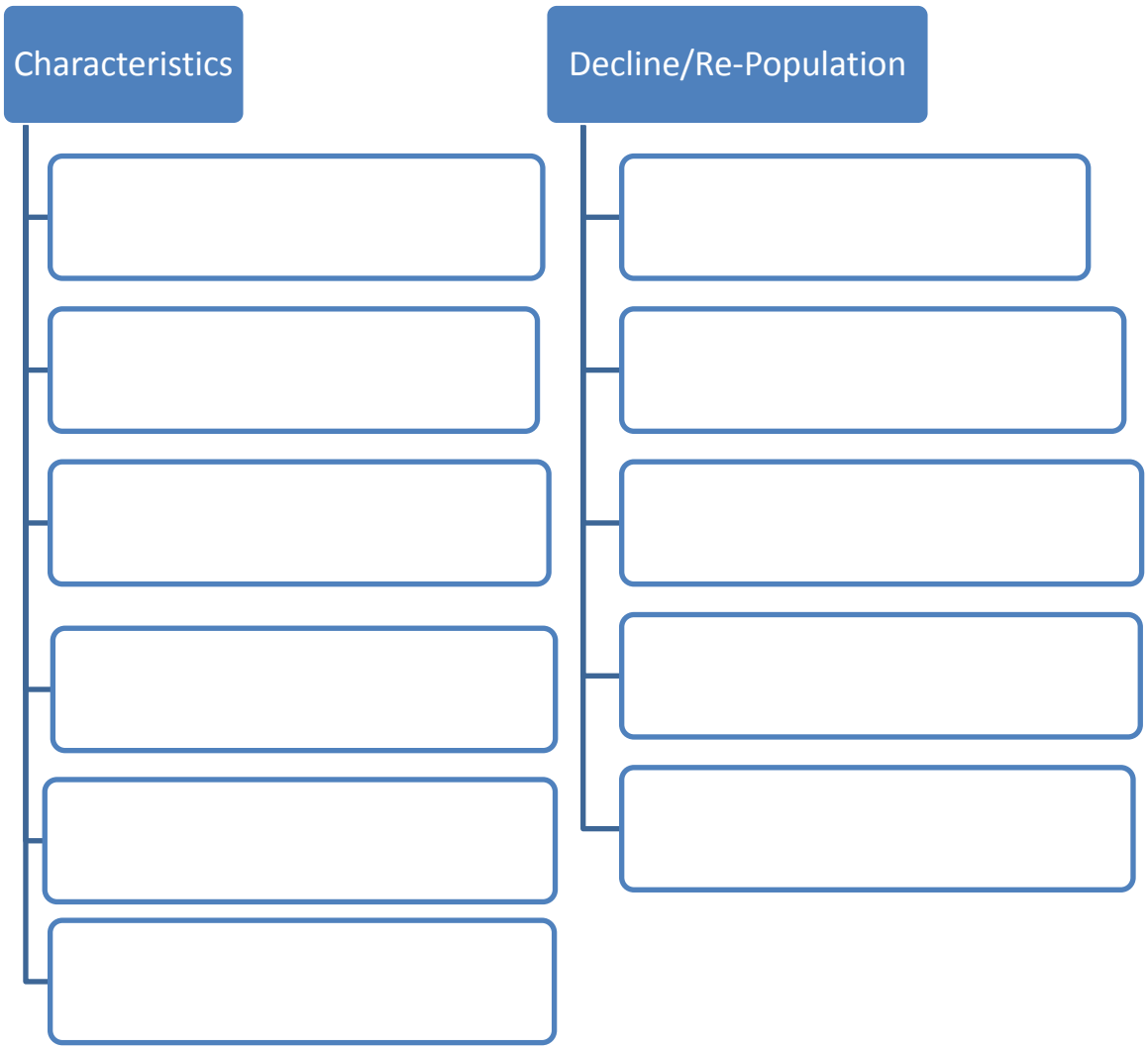
Sample Concept Map
Elk Characteristics



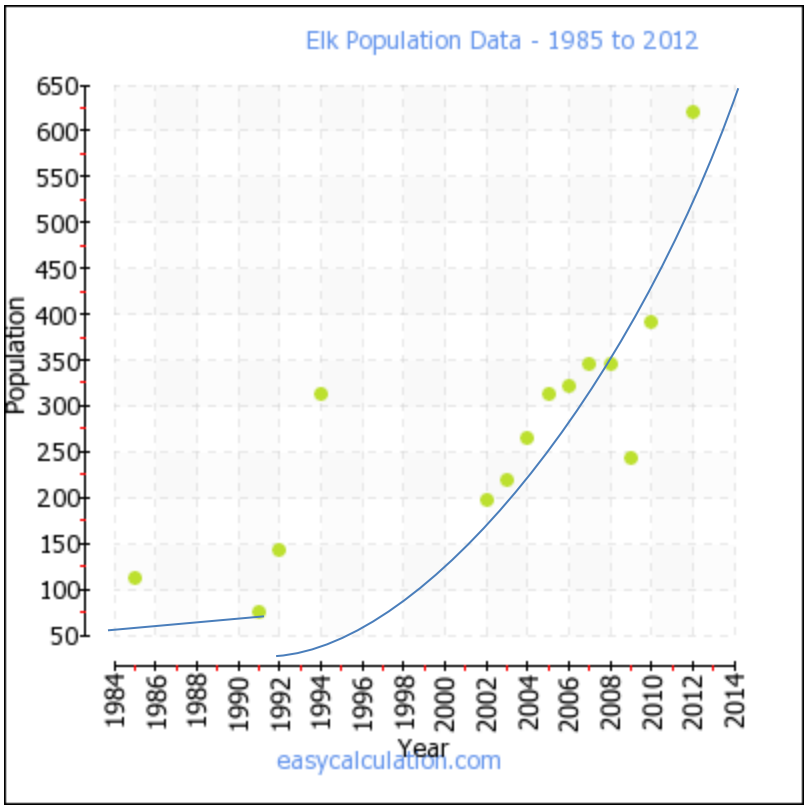
Modified Blank Concept Map
Elk Characteristics



Blank Concept Map
Elk Characteristics



Sample answers:
Graph of data with line of regression shown:



Prediction equation:

$f(x) = (3.3842E^{-46})(1.566^{x})$

Elk population in 10 years:

f(2023) = 796 (algebraically calculating; be sure to use the EE calculator button, not the e)

f(2023) = 784 (extending the window parameters of the graph, on the calculator, using the trace button, and changing the x value to 2023)

Vocabulary Activity/Quiz

Match each vocabulary word with its definition:

_____ 1) exponential	A) increase
____ 2) population	B) naturally occur in a specific area
____ 3) re-population	C) decrease
____ 4) growth	D) changes at a constant rate
____ 5) prediction	E) all the organisms of the same group or species, who live in the same geographical area
____ 6) decay	F) parabolic in shape
____ 7) linear	G) statement about future events
____ 8) native	H) grows or decays by a fixed percent at regular intervals
____ 9) extinct	I) introduction of new animals to an area where they are no longer found
____ 10) quadratic	J) no longer living

Decay Assessment: African Elephant Activity

Background information:
The Africa elephant population has been decreasing for the past century. Using the data given below, determine in what year the elephants will become extinct if nothing is done to stop their decline.

Population numbers:

Year	Population
1900	10,000,000
1970	3,000,000
1979	1,300,000
1989	600,000
1993	500,000
2007	470,000

Procedure:
1) Use the data given to create an appropriate graph showing the population trend; be sure to label your axes with appropriate names and units; what type of graph is it?
2) Generate an equation of "best fit" for the data; what is the equation?
3) Use your equation to predict in what year the African elephant will become extinct

**Note for teacher: This assessment can be accomplished either by utilizing a calculator and hand graph or by utilizing a computer and computer graph.*

Additional Activity:
A similar activity can be done utilizing M&Ms. Give each student group an unopened bag of M&Ms. Have them dump the M&Ms onto a paper plate and do the following:

1) Count the total number of M&Ms. (This is the data number for count #1.)
2) Remove/eat all the M&Ms that have landed such that the M is up/showing; count the remaining M&Ms. (This is the data number for count #2.)
3) Repeat steps 1 and 2 until all the M&Ms are gone

Use the generated data to create an exponential decay graph; ask the question "How many "counts" did it take for the M&Ms to become "extinct"?

Resources

Arkansas Game and Fish Commission; Aerial Elk Surveys
http://www.agfc.com/resources/Pages/ResourcesScientificReports.aspx

Arkansas Game and Fish Commission; Elk of Arkansas Video
http://vimeo.com/56654684

Elk (Cervas elaphus)
http://www.eduscapes.com/nature/elk/index1.htm

National Park Service
http://www.nps.gov/buff/naturescience/elk.htm

Exponential Decay of African Elephants
http://prezi.com/c5b3ltq0w_ci/exponential-decay-of-african-elephants/

Exploring Exponential Decay;
http://education.ti.com/en/us/activity/detail?id=6303CEFBBBDA40D0BF22B1213D480766

On line graphing calculator
http://easycalculator.com